

What Is Claimed Is:

1. A method for smoothly shaping a solid surface by using a gas cluster ion beam, comprising:

5 a process of irradiating said gas cluster ion beam by making the angle formed by said solid surface and said gas cluster ion beam less than  $30^\circ$  for at least a portion of the time period of said gas cluster ion beam irradiation process.

2. A smoothing method according to Claim 1, wherein said gas cluster ion beam irradiation process comprises a process, preceding said process of  
10 irradiation at an irradiation angle of less than  $30^\circ$ , of irradiating said gas cluster ion beam on said solid surface by making the angle formed by said solid surface and said gas cluster ion beam equal to or greater than  $30^\circ$ .

3. A smoothing method according to Claim 1, comprising a process of repeating one or more times a continuous change between said irradiation  
15 angle equal to or greater than  $30^\circ$  and said irradiation angle of less than  $30^\circ$ .

4. A smoothing method according to Claim 1, wherein said process of irradiation at an irradiation angle of less than  $30^\circ$  comprises a process of irradiation in a first direction in the plane of projection of said gas cluster ion beam on said solid surface, and a process of irradiation in a second direction,  
20 different from said first direction, in said plane of projection.

5. A smoothing method according to Claim 4, wherein said process of irradiation at an irradiation angle of less than  $30^\circ$  comprises a process of irradiation wherein the direction in said plane of projection is continuously varied between said first direction and said second direction.

25 6. A smoothing method according to Claim 4, wherein said process of irradiation at an irradiation angle of less than  $30^\circ$ , in which said first and second directions mutually form an angle equal to or greater than  $5^\circ$ , comprises a process of irradiation in a third direction forming an angle equal

to or greater than  $5^\circ$  or more with said first direction and being different from said second direction.

7. A smoothing method according to any of Claims 1 to 6, wherein said solid surface is a side wall surface of a concave portion or a convex portion  
5 formed in a sample surface.

8. A smoothing method according to any of Claims 4, 5, and 6, wherein the irradiation angle formed between said gas cluster ion beam and said solid surface is made to be fixed for said process of irradiation at an irradiation angle of less than  $30^\circ$ .

10 9. A smoothing apparatus for smoothing a solid surface by using a gas cluster ion beam, comprising:

a gas cluster ion beam generating apparatus emitting a gas cluster ion beam; and

an irradiation angle setting means capable of setting the irradiation  
15 angle formed by said solid surface with respect to said gas cluster ion beam to less than  $30^\circ$ .

10. A smoothing apparatus according to Claim 9, wherein said irradiation angle setting means is made capable of setting an irradiation angle to a value equal to or greater than  $30^\circ$  and comprises a means of switching  
20 between said irradiation angle equal to or greater than  $30^\circ$  and said irradiation angle of less than  $30^\circ$ .

11. A smoothing apparatus according to Claim 9, wherein said irradiation angle setting means comprises a means of continuously repeating at least one or more times a change between an irradiation angle equal to or  
25 greater than  $30^\circ$  and said irradiation angle equal to or greater than  $30^\circ$ .

12. A smoothing apparatus according to Claim 9, wherein said irradiation angle setting means comprises a means which can make settings in

at least two directions in the plane of projection of said gas cluster ion beam on said solid surface.

13. A smoothing apparatus according to Claim 9, wherein said irradiation angle setting means comprises a means of irradiation wherein the  
5 direction in said plane of projection is continuously varied between said first direction and said second direction.